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(54) Method and apparatus for electronic component mounting.

(57) An integrated circuit device (16) is selected and positioned adjacent a first side of a circuit board (18) at a desired mounting point utilising a robotic manipulator (12) and a placement head (14). A support fixture (22) is then urged into temporary contact with a second side of the circuit board utilising a flexible mounting system such that minor variations or misalignments between the plane of the support fixture, the circuit board and the placement head are reduced. In one embodiment of the present invention a flexible fluid filled bag (74) is utilised in conjunction with the support fixture so that the presence of components (20) on the second side of the circuit board may be accommodated while supporting the circuit board during component mounting. Finally, the requirement for providing a robotic manipulator and placement head capable of generating the substantial downward forces necessary to create a bond between a circuit board and an electronic component by movement thereof is avoided by positioning the placement head and heated bonding tool (20) proximate to the conductive leads of an electronic component and then forcefully urging the support fixture upward toward the heated bonding tool while maintaining the heated bonding tool in a fixed position.

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The present invention relates in general to the field of integrated circuit device mounting techniques and in particular to methods and apparatus for supporting and positioning a circuit board during mounting of an integrated circuit device.

The increasing complexity of electronic systems and the concomitant increase in component density has resulted in the common utilisation of robotic systems for the manufacturing of such systems. Those skilled in the art will appreciate that robotic systems provide a high degree of efficiency and speed for repetitive operations, such as the mounting of integrated circuit devices to circuit boards.

Many techniques exist for the mounting of electronic components to circuit boards. One such technique is the so-called "hot bar thermode" bonding technique which utilises a placement head to position an integrated circuit having a plurality of conductive leads at a desired mounting point on a printed circuit board. Thereafter, multiple heat activatable blades are urged into contact with the conductive leads and heated to a point where the electronic component is bonded to the circuit board by means of presoldered connections thereon. Such hot bar thermode bonding requires back-side support of the circuit board or substrate which is capable of withstanding substantial forces. Typically, a force of up to 200 Newtons may be applied during the heating of the thermode blades in order to generate the required heat transfer necessary to melt the solder at the connections.

In known prior art systems a support anvil is typically provided and generally comprises a rigid fixture with a rubber gasket. The rubber gasket was assumed to deliver an even force to the back side of the bond area but it has recently been discovered that where misalignment occurs between the thermode blade and the back side support a significant variation in the force levels along the thermode blade may be generated. This condition is undesirable in that it results in an unreliable mounting of an electronic component.

Additionally, such hot bar thermode bonding tools are typically quite complex in that the heat activatable thermode blade are often resiliently mounted to accomodate such misalignments and the placement head must be capable of accurate positioning of an electronic component while exerting the large forces necessary to accomplish bonding.

A need exists for an improved method and apparatus for supporting a circuit board during the mounting of an electronic component which will accommodate variations in planarity between the support fixture, the circuit board and the bonding tool. Further, such an improved system should be able to accommodate the presence of electronic components on both sides of a circuit board which can further complicate any attempt at providing support during the mounting of an electronic component.

Viewed from one aspect the present invention provides apparatus for positioning a circuit board and an electronic component during the mounting of the electronic component to a first surface of the circuit board, the apparatus comprising: component mounting means disposed proximate to a selected mounting position; means for moving the component mounting means so as to position an electronic component held thereat at the selected mounting position; a support for supporting a circuit board; means for selectively and temporarily urging the support and a circuit board supported thereupon to the selected mounting position; and flexible mounting means for coupling the support to the selective and temporary urging means thereby reducing any planar misalignment between the support and a circuit board supported thereupon.

Viewed from another aspect the present invention provides a method for mounting an electronic component having a plurality of conductive leads to a circuit board, the method comprising the steps of: positioning an electronic component held at component mounting means at a selected mounting position; urging a circuit board mounted on a support into contact with the electronic component at the selected mounting position; bonding conductive leads of the electronic component to the circuit board using a heating element coupled to the component mounting means.

In order that the invention may be fully understood preferred embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a partially cut-away view of the circuit board support apparatus in accordance with the present invention;

Figure 2 is an exploded view of one embodiment of a support fixture;

Figure 3 is an exploded view of a second embodiment of a support fixture;

Figures 4a and **4b** depict sectional views of two variations of a third embodiment of a support fixture; and

Figure 5 is a schematic representation of a variable force support fixture;

With reference now to the figures and in particular with reference to **Figure 1**, there is depicted a partially cut-away view of component placement system **10** in accordance with the present invention. As is illustrated, component placement system **10** includes a manipulator arm **12** which is connected, in a manner known in the art, to a robotic system which permits an electronic component to be picked up and manipulated with great exactitude to a desired mounting point on a circuit board. Mounted to the end of manipulator arm **12** is placement head **14**. Placement head **14** preferably includes a heated bonding tool, such as a hot bar thermode, which may be utilised to bond an electronic component **16** to circuit board **18** by heating presoldered connection points which are disposed on circuit board **18**.

Also depicted within **Figure 1** are various back side components **20** which, in accordance with the high density manufacturing techniques utilised in modern state-of-the-art electronic systems may be mounted on both sides of the circuit board **18**.

Still referring to **Figure 1**, a support fixture **22** is illustrated which may be selectively and temporarily urged into contact with circuit board **18**, by means of actuator **36**. Actuator **36** is preferably controlled by pneumatic cylinder **24**. Support fixture **22** may be raised and lowered, as depicted in **Figure 1**, to permit circuit board **18** to be moved about in the plane in which circuit board **18** is mounted, so that back side components **20** are not disturbed by support fixture **22**.

Pneumatic cylinder **24** is preferably mounted on rotary activator **26**. Rotary activator **26** may be utilised to selectively rotate support fixture **22** such that support fixture 22 may be arranged to accurately underlie a rectangular electronic component which is mounted in any desired orientation on the surface of circuit board **18**. Thus, a uniform force of support may be exerted upon a rectangular electronic component **16** by rotating support fixture **22**, by means of rotary activator **26**, greatly enhancing the effectiveness of component placement system **10**. Of course, those skilled in the art will appreciate that the raising and lowering of support fixture **22** by means of actuator **36** and the rotation thereof by means of rotary activator **26** may be simply and easily controlled by means of computer circuitry, in a manner known in the computer aided manufacturing art.

Pneumatic cylinder **24** is, in the depicted embodiment of the present invention, mounted within circuit board holder frame **30** by means of cantilever mounting beam **28**. A small amount of space is preferably provided between the lower surface of the mounting plate of pneumatic cylinder **24** and the lower member of circuit board holder frame **30**, such that additional compliance may be obtained during the provision of those forces necessary to mount component **16** to circuit board **18**.

Circuit board holder frame **30** is shown mounted to a conventional X-Y table **32**, which is mounted to machine base **34** in a manner known in the art. Those skilled in the art will appreciate that different forms of X-Y table **32** may be provided. For example, a so-called "open frame" X-Y table may be provided which includes an aperture in the surface thereof within which circuit board **18** may be mounted and manipulated in an X-Y plane. This type of system will obviate the necessity of providing cantilever mounting beam **28** since support fixture **22** may be simply and fixedly mounted beneath the aperture in such a device. However, it is the experience of the Applicants that a solid frame X-Y table, such as X-Y table **32**, provides a greater accuracy and thus it is necessary to mount pneumatic cylinder **24** on cantilever mounting beam **28** which extends into circuit board holder frame **30** in the manner depicted.

Upon reference to the foregoing those skilled in the art will appreciate that component **16** may be picked up at a location not illustrated and moved via manipulator arm **12** to a desired mounting point on circuit board **18**. Thereafter, manipulator arm **12** is moved in the Z-axis until component **16** comes into contact with circuit board **18** and at that point a Z-axis brake is applied, holding component **16** is in place. Thereafter, support fixture **22** is raised, via actuator **36** of pneumatic cylinder **24**, and sufficient pressure is brought to bear on component **16** while heating the presoldered connections adjacent thereto in order to bond component **16** to circuit board **18** in a reliable and efficient manner.

Referring now to **Figure 2**, there is depicted an exploded view of one embodiment of a support fixture which may be utilised to implement support fixture **22** of **Figure 1**. As illustrated in **Figure 2**, support fixture **22a** includes an anvil base plate **40**, which is preferably mounted to actuator **36** of **Figure 1**. Present within anvil base plate **40** are mounting apertures **42** which are utilised to received pivot pins **46** which serve to mount universal joint **44**.

Universal joint **44** preferably is mounted utilising a second pair of pivot pins **48** which are adapted to be inserted into mounting apertures **52** of rigid rectangular support **50**. Rigid rectangular support **50** is preferably sized to approximate the outline of an electronic component, so that the bonding force applied may be equally distributed around the periphery thereof.

Those skilled in the art will appreciate that the provision of universal joint **44**, along with its associated pivot pins and mounting apertures will permit rigid rectangular support **50** to rotate freely in two axes. In this manner, slight variations in the planarity of rigid rectangular support **50**, circuit board **18** and placement head **14** may be easily and simply accommodated.

Further, a compliant ring **54** is preferably mounted to the upper surface of rigid rectangular support **50** in order to accommodate various surface irregularities which may exist on the lower surface of circuit board **18**. In this manner, variations in gross planarity between rigid rectangular support **50** and circuit board **18** are accommodated by the pivoting nature of the mounting system of rigid rectangular support **50**, while slight surface irregularities are accommodated by the compliant nature of compliant ring **54**.

In a preferred embodiment of the present invention, compliant ring **54** is preferably implemented utilising an elastomer such as neoprene. Improved compliance is achieved if the horizontal surface of compliant ring **54** is made discontinuous, as an array of columns for example, lowering the shape factor of compliant ring **54**. Shape factor is defined as the ratio of the top surface area to the lateral surface area of a

compliant object.

With reference now to **Figure 3**, there is depicted an exploded view of a second embodiment of a support fixture. As is illustrated, support fixture **22b** includes an anvil base plate **40** similar to that depicted in **Figure 2**, which is preferably mounted to actuator **36** of **Figure 1**. Mounted to anvil base plate **40** is a rectangular support **50** which is preferably sized to approximate the outline of an electronic component, as disclosed in the embodiment depicted in **Figure 2**, so that the bonding force applied may be equally distributed around the periphery of the electronic component.

Mounted within rectangular support **50** is an offset universal joint **58** which is utilised to provide a constant force per linear dimension to the periphery of an electronic component in a manner which will be explained in greater detail below. Mounted to either side of offset universal joint **58**, by means of mounting pins **60**, are rocker arms **56**. Rocker arms **56** are preferably held in place on mounting pins **60** by means of a circlip **62**. As illustrated, each rocker arm **56** includes a decentralised pivot point so that a short rocker arm and long rocker arm structure are provided.

Offset universal joint **58** is then mounted within rectangular support **50** by means of pivot pin **64** and circlip **66**. In this manner, offset universal joint **58** is permitted to pivot about pivot pin **64** along its longitudinal axis.

Mounted to the upper surface of rectangular support **50** are two pairs of parallel beams **68** and **100**. As is illustrated, each parallel beam is mounted to a pivot pin **102** which passes through an aperture in rectangular support **50** and which is secured in place by means of circlips **104**. The lower point of each pivot pin **102** then rests upon one of the upper surfaces of each rocker arm **56**. In the embodiment depicted in **Figure 3**, each pivot pin **102** for parallel beams **100** rests upon the longer arm of an associated rocker arm **56** while each pivot pin **102** associated with parallel beams **68** rests upon the shorter arm of rocker arm **56**. In this manner, when equilibrium is achieved a greater pressure is exerted upwardly onto parallel beams **68** due to the off centre rotation point of each rocker arm **56**. By exerting a greater pressure on each of the longer pair of parallel beams the force per linear dimension for parallel beams **68** and **100** may be effectively equalised. As illustrated, parallel beams **68** and **100** are fixed to the upper surface of pivot pin **102** by means of mounting pins **106**.

As is illustrated in **Figure 3**, each parallel beam **68** or **100** also includes a plurality of alignment pins **110** which are mounted within apertures **112** of rectangular support **50** to maintain the parallel relationship of parallel beams **68** and parallel beams **100**. Further, a compliant strip **108** is preferably mounted to the upper surface of each parallel beam **68** or **100** to compensate for slight surface irregularities, as discussed above. In a manner similar to the surface of compliant ring **54** each compliant strip **108** may achieve improved compliance by having a discontinuous upper surface to enhance the shape factor thereof, as illustrated above.

Support fixture **22b** provides a method whereby a consistent force may be applied to a mounting point adapted for utilisation with a rectangular component. By providing an off centre rotational point for each rocker arm **56** a force may be provided along the long side of a rectangular component which is proportionally larger than the force applied to the short side of the rectangular component so that a constant force per linear dimension is provided, further enhancing the equal distribution of bonding force during the mounting of a rectangular component.

Referring now to **Figures 4a** and **4b**, there are depicted section views of two variations of a third embodiment of a support fixture which may be utilised with the method and apparatus of the present invention. As is illustrated in **Figure 4a** support fixture **22c** preferably comprises a flexible fluid filled bag **74** which is filled with fluid **78**. Fluid **78** preferably comprises ethylene glycol a fluid which is selected for appropriate heat dissipation and other characteristics. As illustrated within **Figure 4a** flexible fluid filled bag **74** may be urged upward into contact with the lower surface of circuit board **18**, despite the presence of back side components **20**. In this manner an equally distributed support force may be provided during the bonding of component **16** within placement head **14**. Such bonding typically is accomplished by the utilisation of heat activatable thermode blades **70**. By urging heat activatable thermode blades **70** into contact with conductive leads **72** of component **16**, while providing an evenly distributed pressure to the lower side of circuit board **18** by means of flexible fluid filled bag **74**, component **16** may be efficiently and accurately bonded to circuit board **18**, despite the presence of back side components **20** which might otherwise render the support of circuit board **18** difficult to accomplish.

As is illustrated, flexible fluid filled bag **74** is preferably mounted to a base plate **76** which will be attached to actuator **36** (not shown). A fill tube **80** is also provided and it utilised to increase or decrease the amount of fluid present within flexible fluid filled bag **74**, to permit minor variations in the amount of pressure to be exerted on the lower side of circuit board **18**.

Referring now to **Figure 4b** there is depicted a second variation of support fixture **22d** which may be utilised with the method and apparatus of the present invention. In the embodiment depicted within **Figure 4b** flexible fluid filled bag **74** includes a plurality of flexible fingers **82**. This technique may also be utilised to provide an evenly distributed support force to the lower surface of circuit board **18** while accommodat-

ing the presence of various backside components **20**. As above, flexible fluid filled bag **74** is preferably mounted to base plate **76** and includes a fill tube **80** for increasing or decreasing the amount of fluid within flexible fluid filled bag **74**. In the embodiment depicted in **Figures 4a** or **4b** flexible fluid filled bag **74** may preferably be provided utilising any resilient flexible material capable of withstanding the pressures and temperatures encountered during component bonding.

Finally, with reference to **Figure 5**, there is depicted a schematic representation of a variable force support fixture. In prior art electronic component bonding machines, the amount of force applied to an electronic component during placement and mounting is typically generated by a robotic arm, such as manipulator arm **12**. A support anvil or fixture is typically mounted to a pneumatic cylinder and urged against the lower surface of circuit board **18** by a specified force which is determined by regulating the amount of pressure applied to the pneumatic cylinder.

While this technique works satisfactorily, the necessity of creating a manipulator arm and placement head which are capable of the fine manipulation of an electronic component which is necessary in order to achieve the accuracy in placement which is desired for modern electronic systems while simultaneously generating the large amounts of force necessary to ensure proper thermal conductivity during bonding, has resulted in an increasingly complex and expensive system.

In accordance with the present invention manipulator arm **12** is utilised to position placement head **14** and component **16** in proximity to a desired mounting position on circuit board **18** (see **Figure 1**). Thereafter, placement head **14** is held rigid in a fixed position. A support fixture of one of the types illustrated herein is then urged upward into contact with the lower surface of circuit board **18**, by means of actuator **36**, and a precisely regulated amount of pressure is exerted, urging circuit board **18** into contact with the conductive leads of component **16**. At this time the heat activatable bonding blades of placement head **14** are actuated. By generating all of the bonding force necessary to achieve an accurate electronic bonding of component **16** to circuit board **18** by means of a support fixture below the circuit board the increased complexity necessary in prior art systems is greatly reduced.

The system depicted in **Figure 5** illustrate one technique whereby this may be accomplished. A computer or other suitable programmable device **84** is preferably utilised to select a desired amount of pressure which will be exerted on the lower surface of circuit board **18**. This pressure is preferably expressed as a multibit digital signal. The depicted embodiment of the present invention utilises an 8 bit signal which is coupled to regulator **90** by means of control cable **86**. Regulator **90** is preferably a regulator having a controllable output pressure which corresponds closely to an input signal received from computer **84**. Regulator **90** is preferably implemented utilising a Proportionair BB1MFD, which will output one of 256 different pressure levels in response to an 8 bit digital input.

By providing an air supply **88** which is capable of generating pressurised air at 6.89×10^5 Pa (100 pounds per square inch), 256 different pressures may be output from regulator **90**, resulting in a highly accurate regulation of the amount of force which is exerted by actuator **36** on a support fixture. The output of regulator **90** is preferably coupled to pneumatic cylinder control valve 94 which regulates the pressure coupled to and from pneumatic cylinder 24

In this manner a component may be selectively bonded to the upper surface of circuit board **18** by placing that component in proximity to a plurality of presoldered connectors and actuating a heated bonding blade which is held in a fixed position adjacent to the conductive leads. Thereafter, a precise amount of pressure may be exerted on a support fixture located beneath circuit board **18**, to generate the exact amount of pressure necessary for proper thermal conductivity and an accurate bond will result. In this manner, the design of manipulator arm **12** and placement head **14** (see **Figure 1**) are greatly simplified due to the fact that the ability to provide large downward forces by the movement thereof is eliminated.

With the method and apparatus of the present invention, a requirement levied upon manipulator arm **12** and placement head **14** is the ability to lock the manipulator arm in place in the Z-axis during exertion of large forces during bonding. This may be simply and easily accomplished utilising the brake mechanism which is commonly employed in such devices to prevent manipulator arm **12** from falling onto circuit board **18** when power is removed from manipulator arm **12**. These braking devices are commonly under program control of the robotic system and may be simply activated to resist the large forces applied during bonding in order to protect the precision motors of manipulator arm **12**.

An improved method and apparatus for mounting integrated circuit devices which permits the supporting of a circuit borad from one side while a component is mounted to the second side has been described. Misalignment between the support fixture, the circuit board and the bonding tool has been accommodated.

The method and apparatus which have been described may be utilised to support a selected mounting point an a circuit board during the mounting an electronic component. An integrated circuit device is selected and positioned adjacent a first side of a circuit board at a desired mounting point, utilising a robotic manipulator and a placement head. A support fixture is then urged into temporary contact with a second side of the circuit board utilising a flexible mount-

ing system such that minor variations or misalignments between the plane of the support fixture, the circuit board and the placement head are reduced during operation of a heated bonding tool. A compliant layer mounted to the support fixture may be utilised to accommodate surface irregularities on the circuit board. In accordance with one embodiment of the present invention a flexible fluid filled bag is utilised in conjunction with the support fixture so that the presence of components on the second side of the circuit board may be accommodated while support the circuit board during component mounting. In order to fully support the mounting of rectangular electronic components in multiple orientations the support fixture may be selectively rotated. Finally, the requirement for providing a robotic manipulator and placement head capable of generating the substantial downward fores necessary to create a bond between a circuit board and an electronic component by moving the placement head downwards is eliminated by positioning the placement head and heated bonding tool proximate to the conductive leads of an electronic component and then forcefully urging the support fixture upward while maintaining the heated bonding tool in a fixed position.

Claims

1. Apparatus for positioning a circuit board and an electronic component during the mounting of the electronic component to a first surface of the circuit board, the apparatus comprising:
component mounting means disposed proximate to a selected mounting position;
means for moving the component mounting means so as to position an electronic component held thereat at the selected mounting position;
a support for supporting a circuit board;
means for selectively and temporarily urging the support and a circuit board supported thereupon to the selected mounting position; and
flexible mounting means for coupling the support to the selective and temporary urging means thereby reducing any planar misalignment between the support and a circuit board supported thereupon.

2. Apparatus as claimed in Claim 1 wherein the component mounting means includes one or more heatable blades for bonding the electronic component to the circuit board at the selected mounting position.

3. Apparatus as claimed in any of Claims 1 or 2 wherein the means for moving the component mounting means comprises a robotic manipulator.

4. Apparatus as claimed in any of the preceding Claims wherein the support comprises a rigid rectangular member having a compliant layer disposed thereon.

5. Apparatus as claimed in Claim 4 wherein the compliant layer is a layer of elastomer.

6. Apparatus as claimed in any of the preceding Claims wherein the flexible mounting means comprises a universal joint having a plurality of pivot pins disposed therein for insertion into a plurality of mounting apertures within the support whereby the support may pivot in at least two axes.

7. Apparatus as claimed in any of the preceding Claims further comprising means for selectively rotating the support in a plane parallel to a circuit board mounted thereon thereby providing for electronic component mounting in multiple orientations.

8. Apparatus as claimed in any of the preceding Claims further comprising a bag containing fluid mounted on the support for accommodating an electronic component mounted on a second surface of the circuit board.

9. Apparatus as claimed in Claim 8 wherein the bag containing fluid includes a plurality of finger-like projections for accommodating an electronic component mounted on a second surface of the circuit board.

10. Apparatus as claimed in any of Claims 8 or 9 further comprising means for supplying fluid to and removing fluid from the bag.

11. Apparatus as claimed in any of the preceding claims wherein the means for urging the support and a circuit board supported thereupon comprises a pneumatic cylinder.

12. A method for mounting an electronic component having a plurality of conductive leads to a circuit board, the method comprising the steps of:
positioning an electronic component held at component mounting means at a selected mounting position;
urging a circuit board mounted on a support into contact with the electronic component at the selected mounting position;
bonding conductive leads of the electronic component to the circuit board using a heating element coupled to the component mounting means.

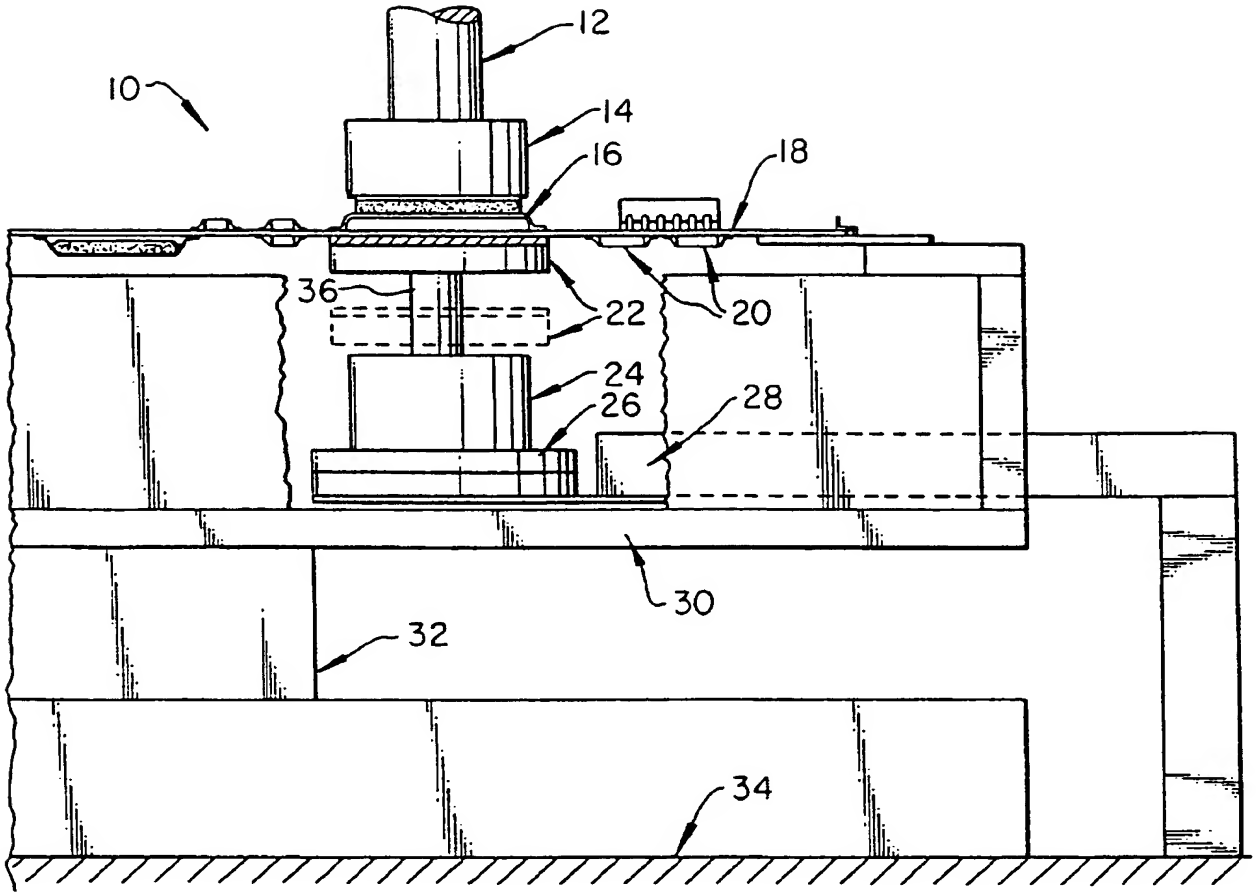

Fig. 1

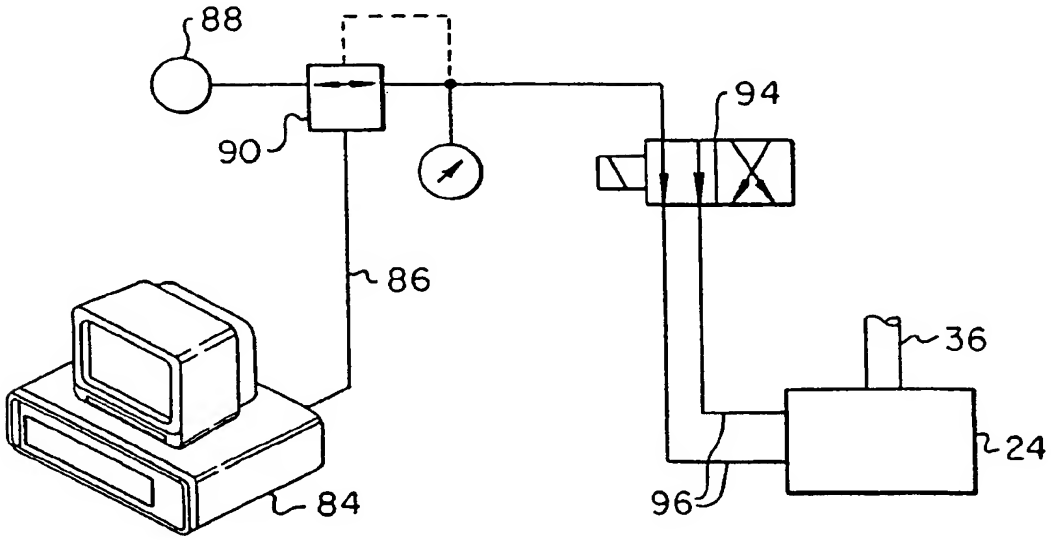

Fig. 5

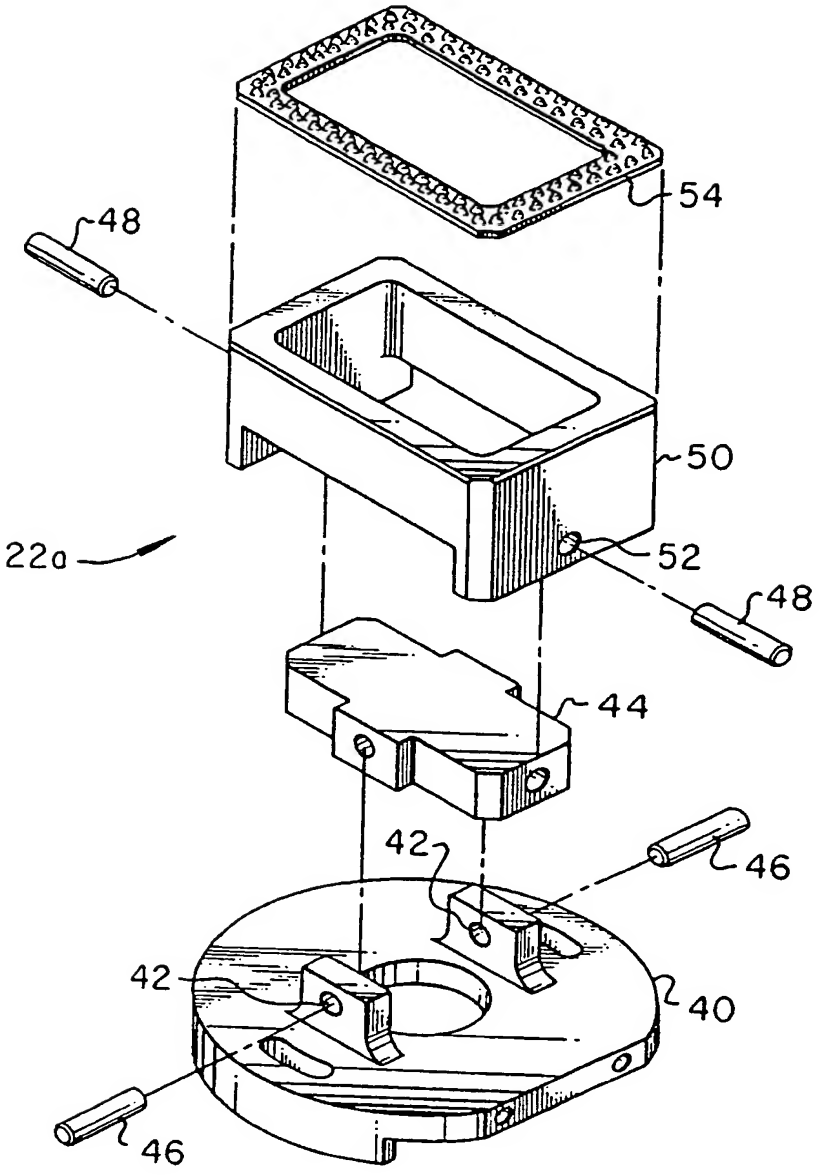

Fig. 2

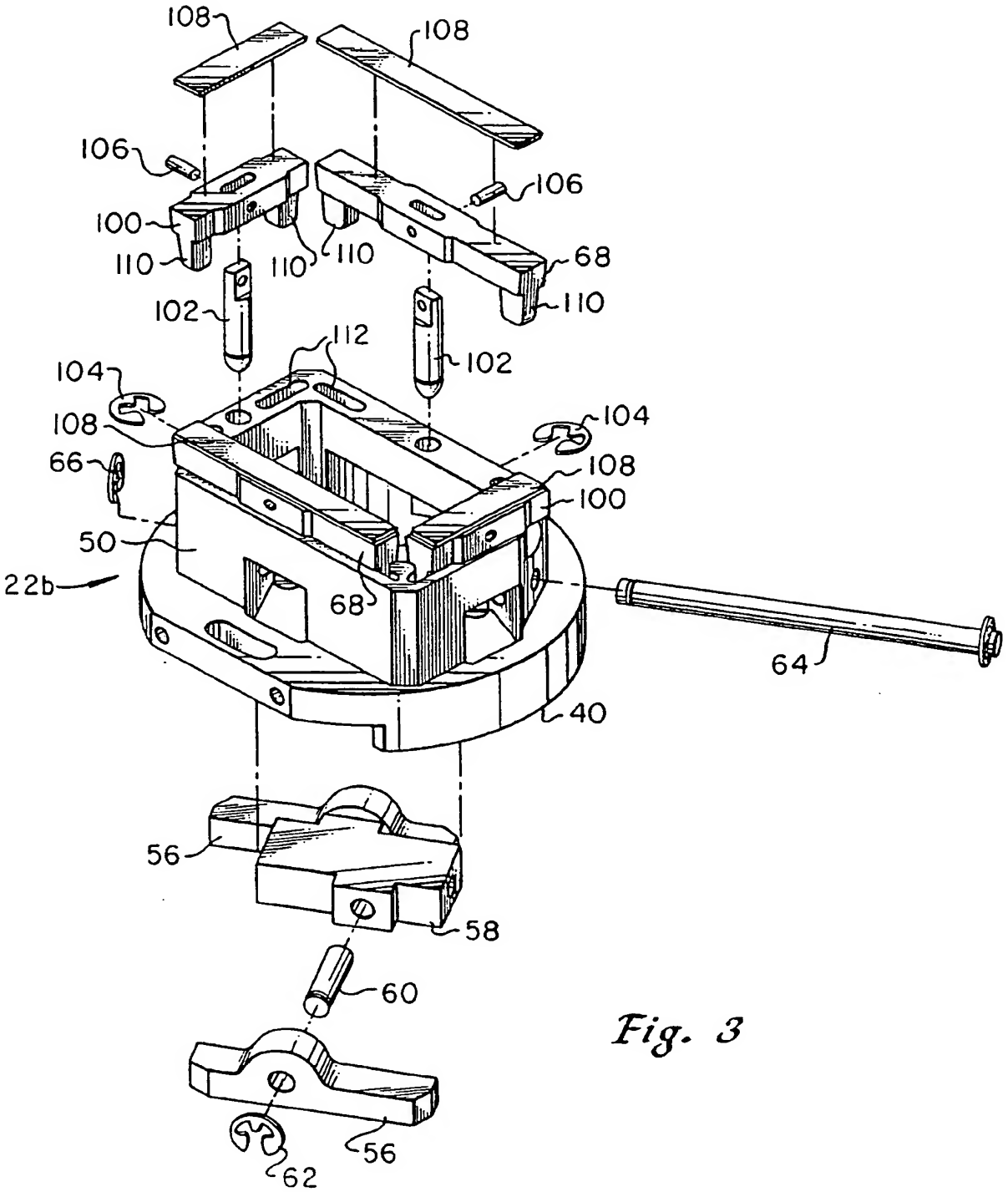

Fig. 3

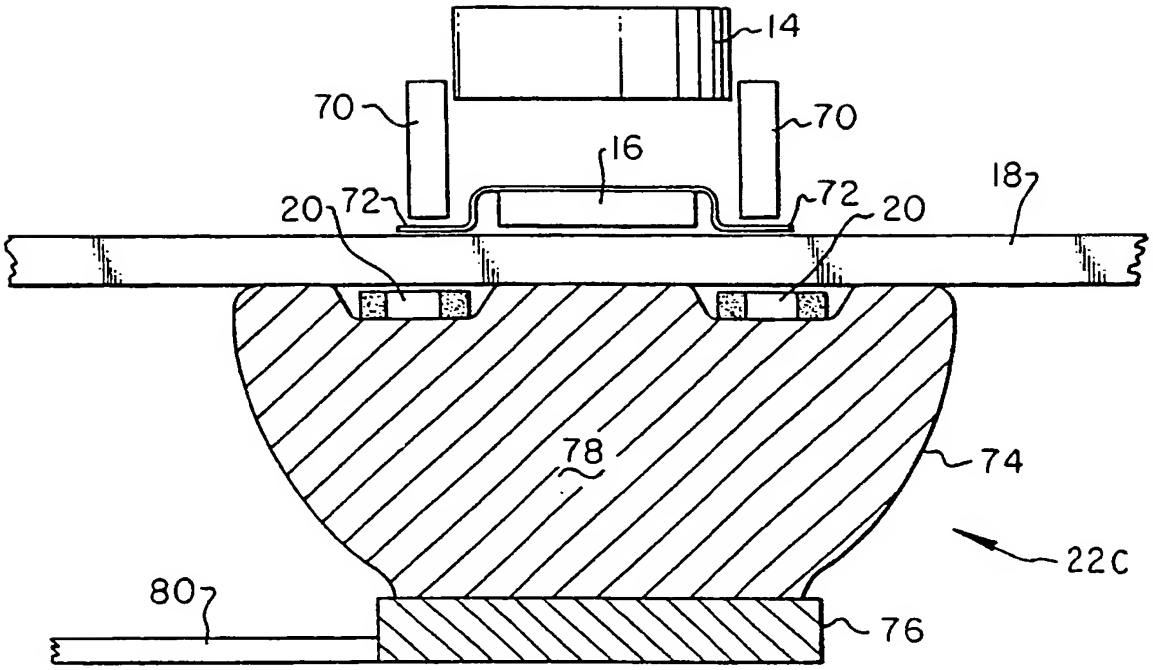

Fig. 4A

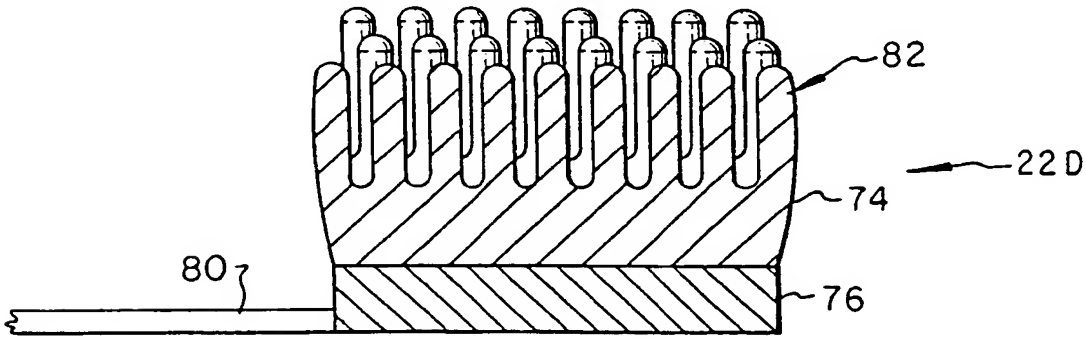

Fig. 4B

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(54) Method and apparatus for electronic component mounting

[57] An integrated circuit device (16) is selected and positioned adjacent a first side of a circuit board (18) at a desired mounting point utilising a robotic manipulator (12) and a placement head (14). A support fixture (22) is then urged into temporary contact with a second side of the circuit board utilising a flexible mounting system such that minor variations or misalignments between the plane of the support fixture, the circuit board and the placement head are reduced. In one embodiment of the present invention a flexible fluid filled bag (74) is utilised in conjunction with the support fixture so that the presence of components (20) on the second side of the circuit board may be accommodated while supporting the circuit board during component mounting. Finally, the requirement for providing a robotic manipulator and placement head capable of generating the substantial downward forces necessary to create a bond between a circuit board and an electronic component by movement thereof is avoided by positioning the placement head and heated bonding tool (20) proximate to the conductive leads of an electronic component and then forcefully urging the support fixture upward toward the heated bonding tool while maintaining the heated bonding tool in a fixed position.

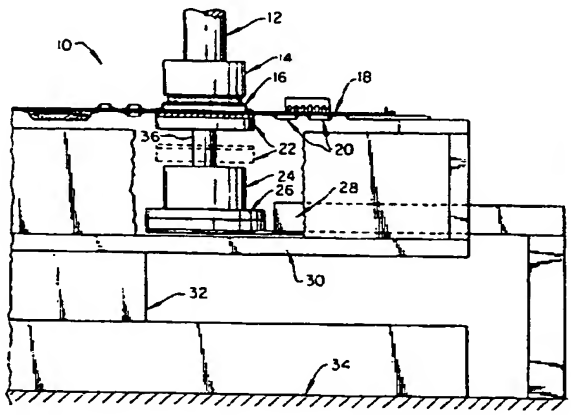

Fig. 1

EP 0 487 315 A3 CORRIGENDUM Issued on 03.12.1997 (bibliography updates included)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0668

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	FR-A-2 015 819 (WESTERN ELECTRIC) * page 3, line 3 - page 3, line 15; figures 1,2,6-12 * * page 4, line 6 - page 6, line 40 *	1-4,8, 10,12	H05K13/00 H05K13/04 H01L21/00 H01L21/60 H01L21/603
A	US-A-3 627 190 (RAMSEY) * column 2, line 73 - column 5, line 55; figures 1-4 *	1-3,11, 12	
A	EP-A-0 366 880 (IBM) * column 11, line 16 - column 11, line 54; figure 13 *	1-3,12	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5) H05K H01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	09 NOVEMBER 1992	HAHN G.

EPO FORM 1503 03.82 (P0401)

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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